



# Part 6: Basic System Design

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# Outline



- **Objectives of LFG Collection/Control**
- **Elements of a LFG collection System**
- **LFG Destruction/Utilization Options**





# Objectives

- **Recover and utilize LFG**
- **Minimize potential environmental impacts**
- **Control off-site migration**
- **Control odors**
- **Comply with regulatory requirements**

# Elements of an LFG Collection System



- Network of interconnecting piping
- LFG collection points
  - Vertical extraction wells
  - Horizontal collectors/trenches
  - Connection to existing vents, wells, etc.
- Elements of condensate management
- Flow control
- LFG blower/combustion device (flare, engine, etc.)

# Vertical Extraction Wells



- **Most common approach for recovering LFG**
- **Install in existing or operational disposal areas**
- **Waste depth preferable > 10 meters**
- **Install approx 2.5 wells per hectare (~ 1 well per 0.4 hectare)**
- **Not appropriate for use in landfills with elevated leachate levels**



# Vertical Extraction Wells - Design Features



- In-refuse wells - 75% of the refuse depth
- Depth of in-soil wells varies
  - Groundwater level
  - Bottom of refuse
  - Depth of gas migration
- Boreholes typically 60 cm to 90 cm diameter
- Casing is generally PVC or HDPE
- Bottom perforated - start 6 meters below ground surface
- Spacing depends upon “radius of influence” (typ. 60 m - 122 m)



TOP DECK  
EXTRACTION WELL

LANDFILL COVER

SIDE SLOPE  
EXTRACTION WELL

LANDFILL MSW

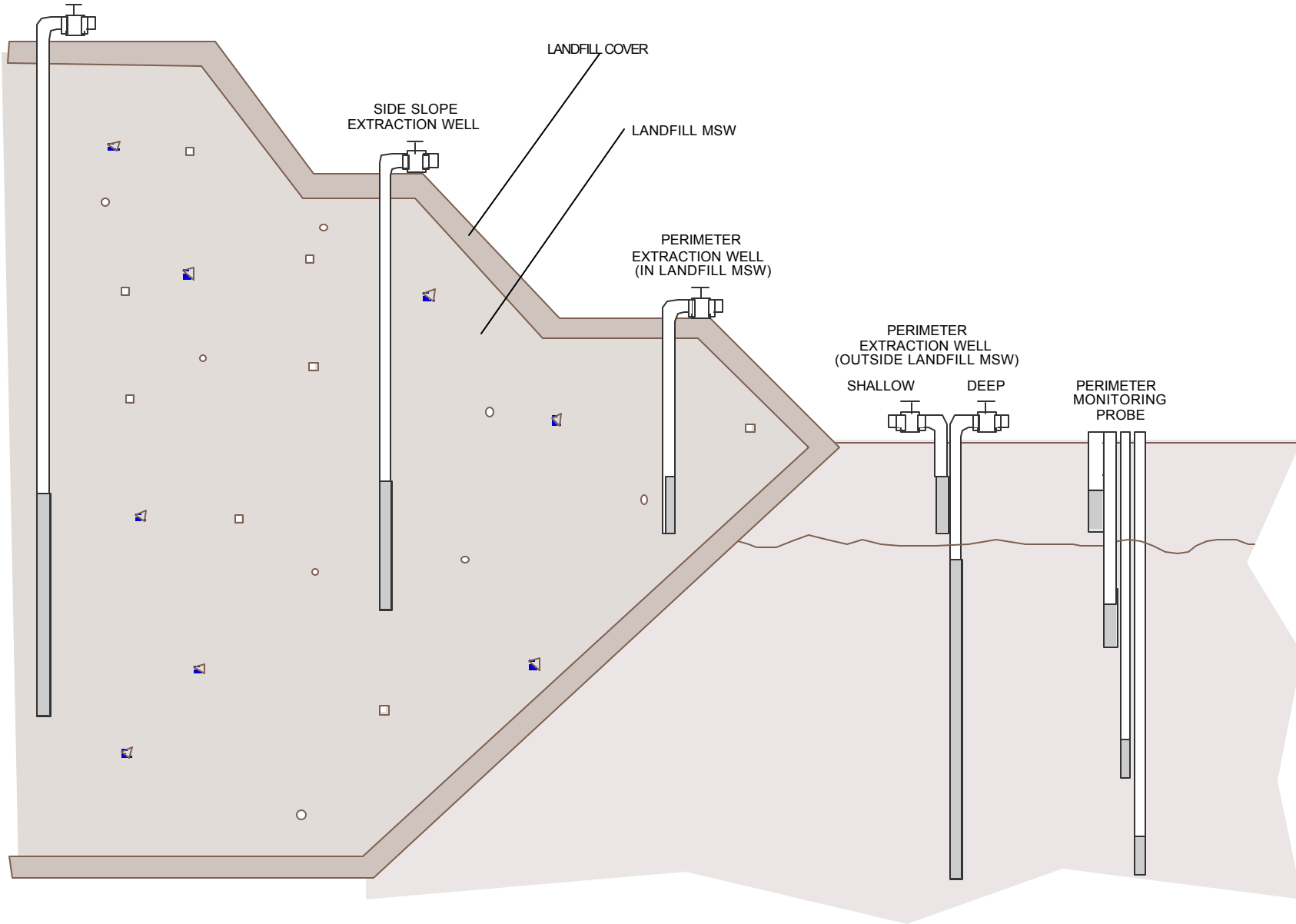
PERIMETER  
EXTRACTION WELL  
(IN LANDFILL MSW)

PERIMETER  
EXTRACTION WELL  
(OUTSIDE LANDFILL MSW)

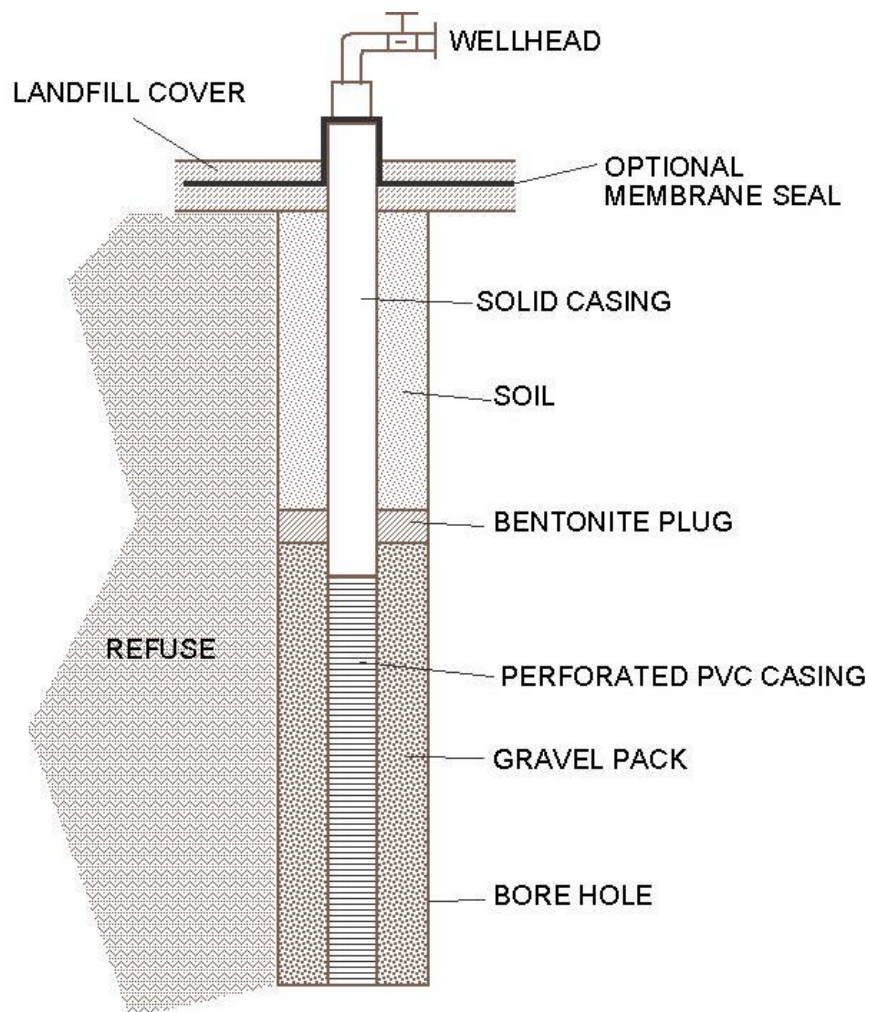
SHALLOW

DEEP

PERIMETER  
MONITORING  
PROBE



# Typical Vertical Extraction Well



- Bentonite seal prevents air infiltration
- Wellhead incorporates:
  - Flow control valve
  - Pressure monitoring port
  - Flow monitoring device (optional)
  - Thermometer (optional)

# Vertical Extraction Wells - Examples

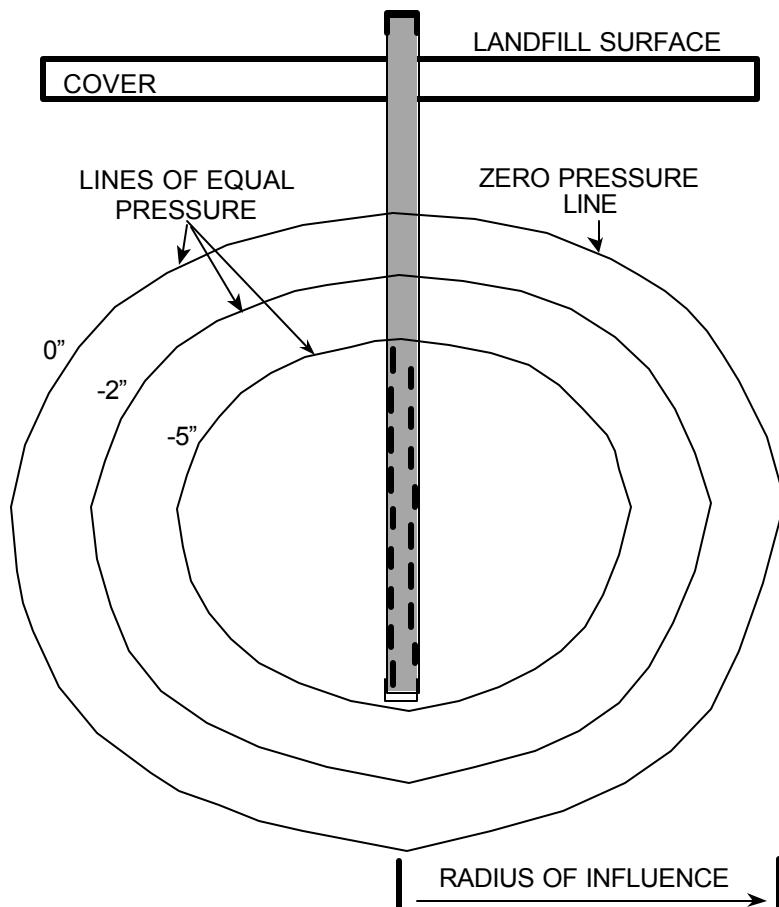


- **Auckland, New Zealand**



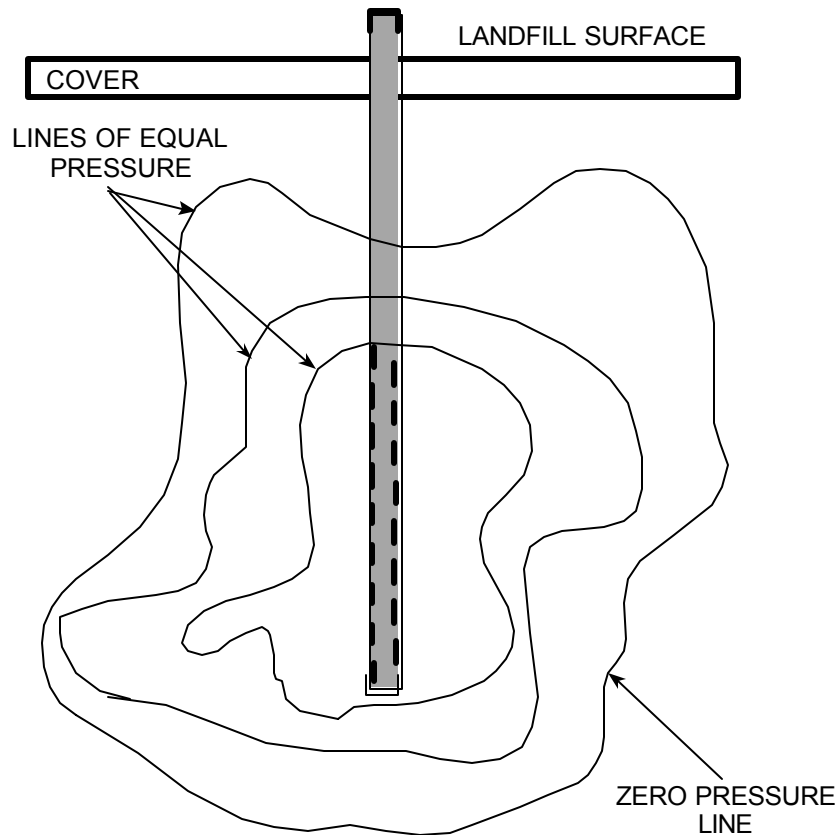
- **Los Angeles, California**

# Theoretical Radius of Influence of a Landfill Gas Well



- Radius of influence 2 to 2.5 times well depth
- Increase vacuum to increase the radius of influence
- Variations in vacuum are the operator's only control tool

# Actual Radius of Influence of a Landfill Gas Well



- A well's radius of influence is unlikely to be ideal:
  - Variations in waste characteristics
  - Interim cover and cell configuration
  - Presence of leachate

# Horizontal Collectors



- **Alternative approach for LFG recovery**
- **Install in shallow areas**
- **Install in existing or operational disposal areas**
- **Install at a spacing of approx 30 to 100 meters**
- **Can be used in landfills with elevated leachate levels**



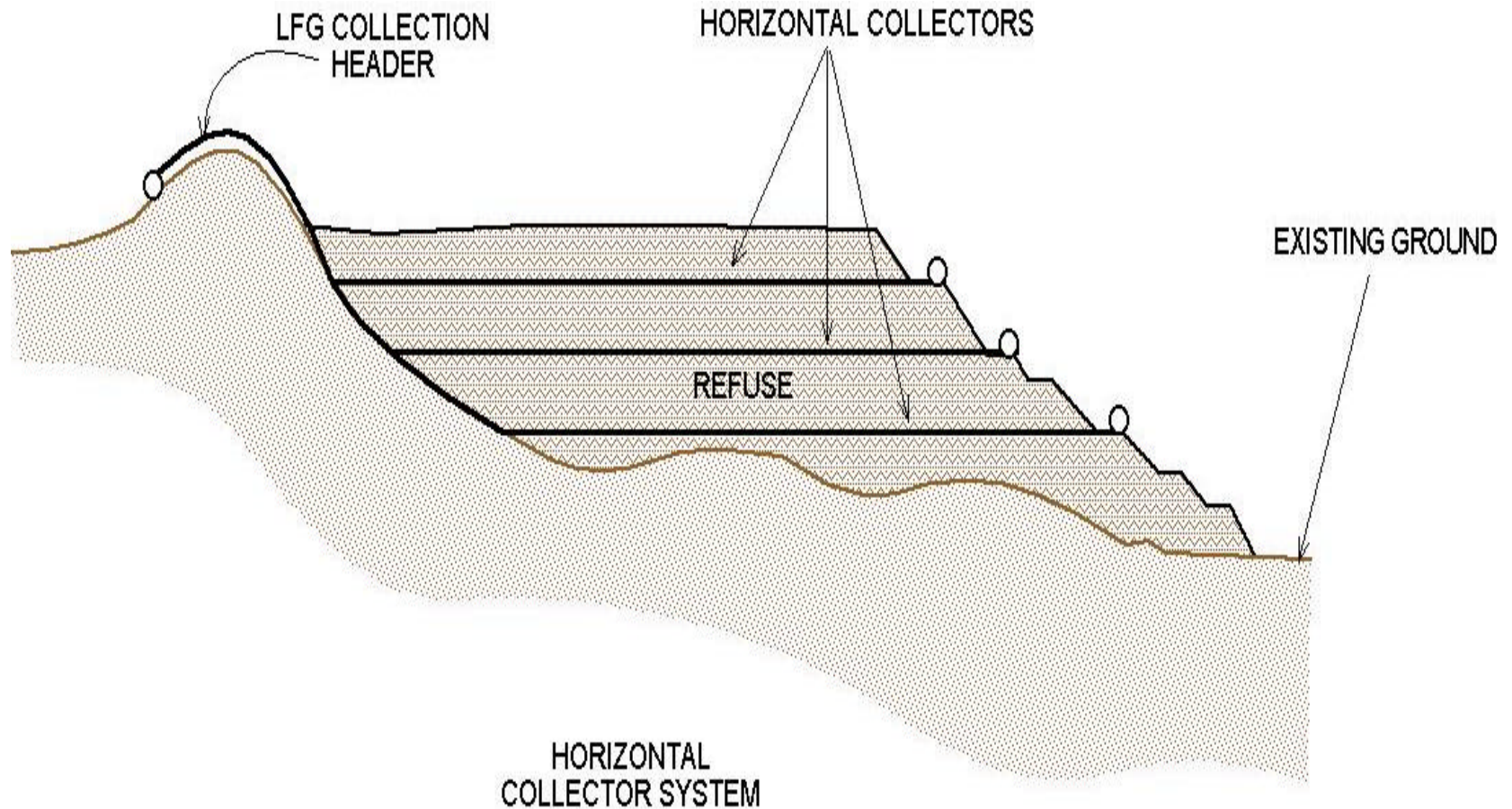
# Horizontal Collectors - Design Features



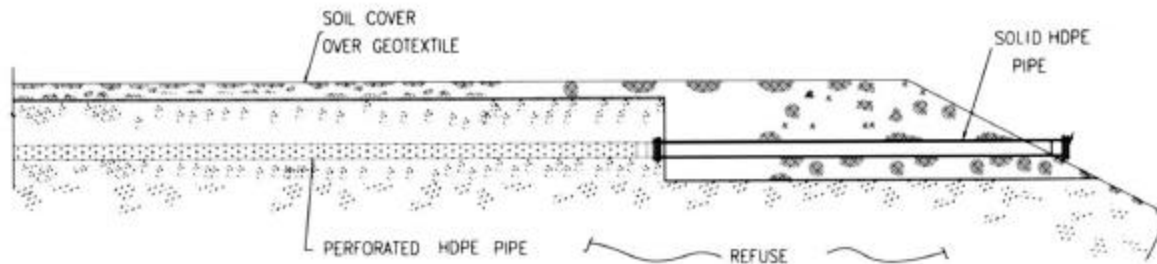
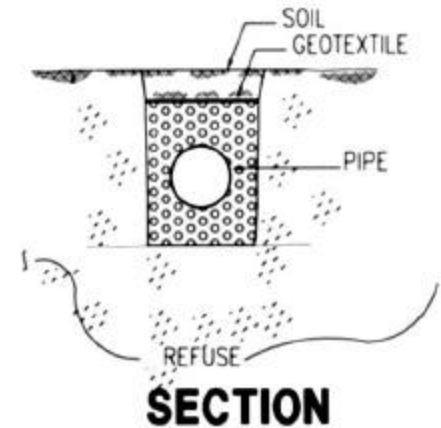
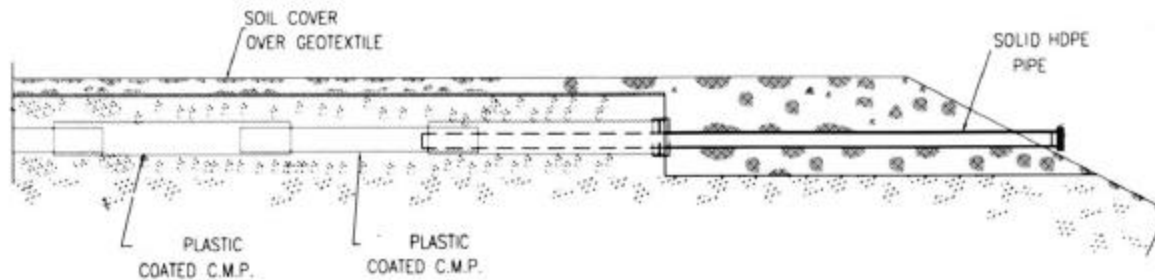
- **Install in trenches or place on grade and cover with gravel and waste**
- **Construct out of approx 100 mm slotted PVC or HDPE pipe**
- **Alternatively construct out of “nested” 100 mm and 150 mm pipes**



# Typical Horizontal Collector Arrangement



# Typical Horizontal Collector Arrangement





# Examples

- **Bangkok, Thailand**



- **Los Angeles, California**

# Other Collection Points

- Recover LFG from other collection points such as leachate chambers, sumps, vents, and drains
- Controls LFG emissions and odors



# Laterals and Headers



- Pathway for LFG from wellheads to blowers
- Can be above-grade or underground
- Generally HDPE - PVC sometimes used above-grade
- Sized on flow rate and pressure drop
- Pipe configuration often “looped” to provide alternative flow paths
- Pipe sloped to promote condensate drainage
- Unusual drops in vacuum normally due to condensate blockages

# Examples



- **Seoul, Korea**



- **Los Angeles, California**

# Condensate System

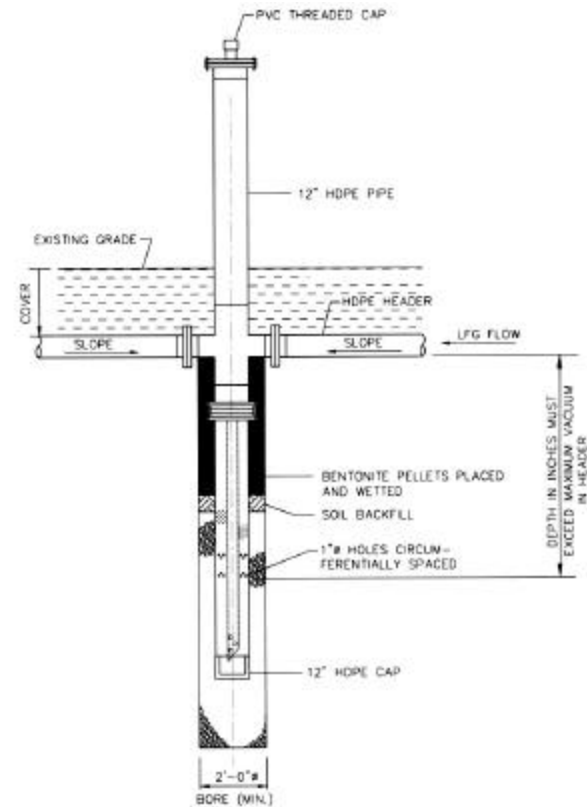
- Condensate volume depends on LFG temperature and flow
- LFG is assumed to be 100% saturated with water
- LFG temperature is typically 90° to 130° F
- LFG cools in the LFG collection piping and the moisture condenses out into the piping
- Drains to low points in the piping and can restrict flow



# Condensate Removal - Design Features



- Piping designed to allow condensate to drain
- Traps allow for drainage by gravity
- Sumps collect condensate



# LFG Destruction/Utilization Alternatives



- Destruction
  - Open flares (aka: candle-stick flares)
  - Enclosed flares (aka: ground flares)
- Beneficial use
  - Generate electric power
  - Direct use/sale of methane
  - Leachate evaporation
- Combined arrangements
  - Flare in parallel with beneficial use
  - Flare as stand-by to beneficial use

# Blower/Flare Station

- **Combusts methane gas**
- **Open or enclosed flame**
- **May be used in combination with beneficial use system**
- **Needed during utilization system startup and downtime**



# Blower/Flare Station - Design Features



- **Location should be central to collection system, close to potential end user or utility service, away from trees**
- **Design with flexibility to handle future gas flows**
- **Typically provide a standby blower**
- **Provide available vacuum to entire well field**



# Blower/Flare Station - Typical Elements



- Moisture separator
- Blowers
- Flare (open or enclosed)
- LFG piping and flame arrestor
- Flow meter
- Pilot fuel supply
- Control panel (controls both blower and flare)
- Auto shutoff valve



# Enclosed Ground Flares

- Flare body usually circular: 9 to 12 meters high
- LFG combusted close to ground
- Flame not visible from outside
- Air louvers near stack base
- Typical operating temperature range: 1,400 °F to 1,600 °F
- Typical destruction of 98 to 99 percent (or greater)
- More expensive than candlestick flares



# Open (Candlestick) Flare Components



- Vertical pipe
- Flare tip at top of pipe - flame visible
- Smaller than enclosed flare - easier to toast marshmallows
- Less expensive than enclosed flare
- Typical destruction of 98 percent
- Cannot test effluent



# Blower Flare Station - Monitoring System



# Gas Utilization

- **Utilization systems consist of:**
  - **Direct Gas Use/Sale**
  - **Electricity Generation**
  - **Pipeline Upgrade**
  - **Other Niche Technologies**
    - ◆ **Greenhouse**
    - ◆ **Leachate Evaporation**
    - ◆ **Fuel Cells**
    - ◆ **Microturbines**



**Cleaver Brooks Boiler Unit**

# Design Features

- Utilization systems are very site specific and depend upon the technology applied
- Designed to “grow” with the landfill as gas flows increase



**Caterpillar 3516 800 kW Genset**

# Examples

## Bangkok, Thailand



## Pipeline Upgrade New York, NY

# Summary

- **LFG collection system design - site specific**
- **Basic Concept**
  - Provide path for LFG collection
  - Manage condensate
  - Burn the gas
- **Always consider your operating goals**

